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UV and X-ray Emission from Impacts of Fragmented Accretion Streams on Classical T Tauri stars

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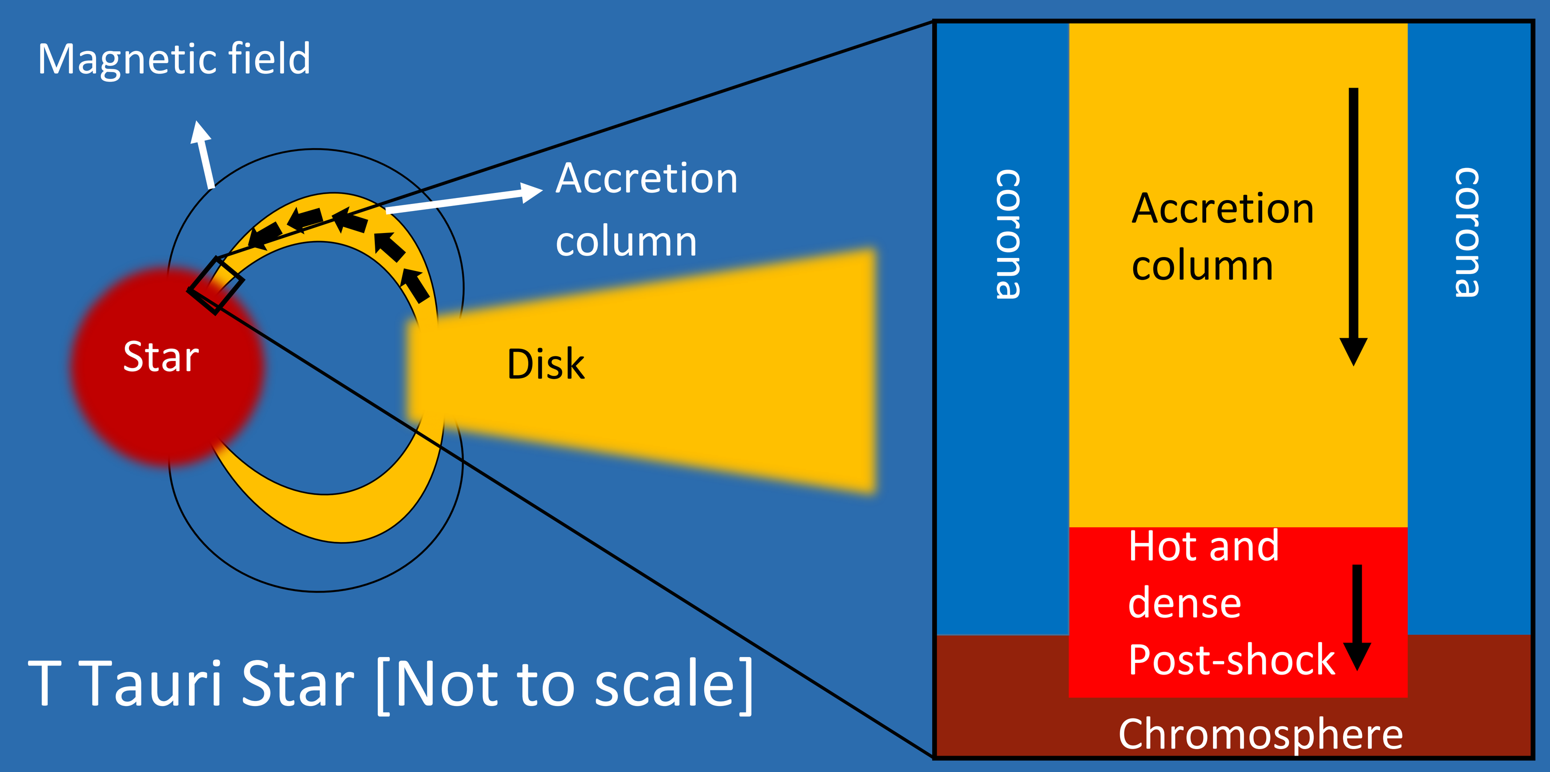
Context

The accretion process in Classical T Tauri Stars (CTTSs) can be studied through the analysis of some UV and X-ray emission lines which trace hot gas (Sacco et al. 2008, Orlando et al. 2010).

In the UV band these lines consist of multiple components of plasma with different Doppler shifts whose origin is not clear (Ardila et al. 2013).

In this work we investigate the origin of UV and X-ray emission arising from regions where accretion streams impact onto the stellar chromosphere (Reale et al. 2013) and if and how the stream fragmentation determines the observed asymmetries and redshift of UV emission lines in CTTSs.



Model

We model the impact of a fragmented accretion stream onto the chromosphere of a CTTS with 2D axysimmetric magneto-hydrodynamic simulations. Our model includes:

- Stellar magnetic field
- Gravity
- Thermal conduction
- Radiative cooling from an optically thin plasma

From the model results, we synthesize the UV and X-ray emission and its Doppler shift along the line of sight.
The simulations were performed using the PLUTO code (Mignone et al,2007).

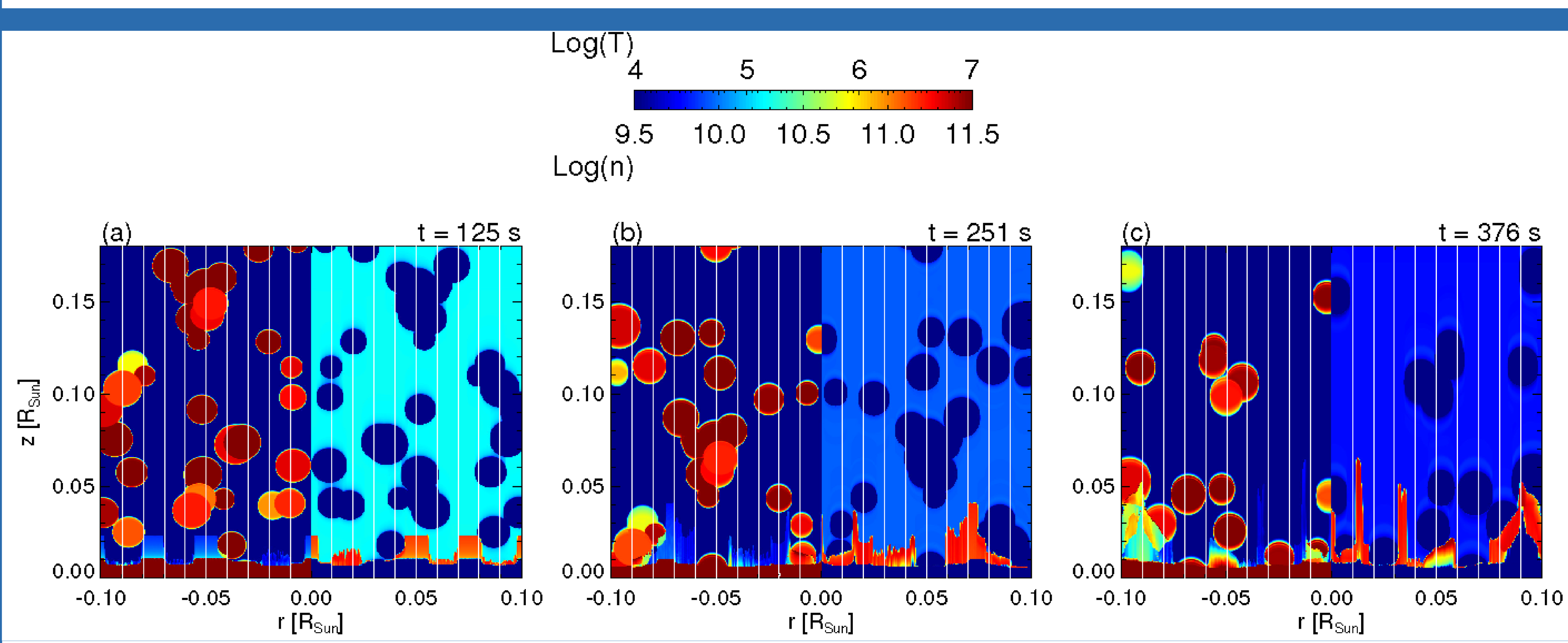


Figure 2: Evolution of density (left half-panel) and temperature (right half-panel) in log scale of plasma for randomly fragmented stream. White lines represent magnetic field lines (Colombo et al. 2016). Note the complex structure of impact region due to stream random fragmentation.

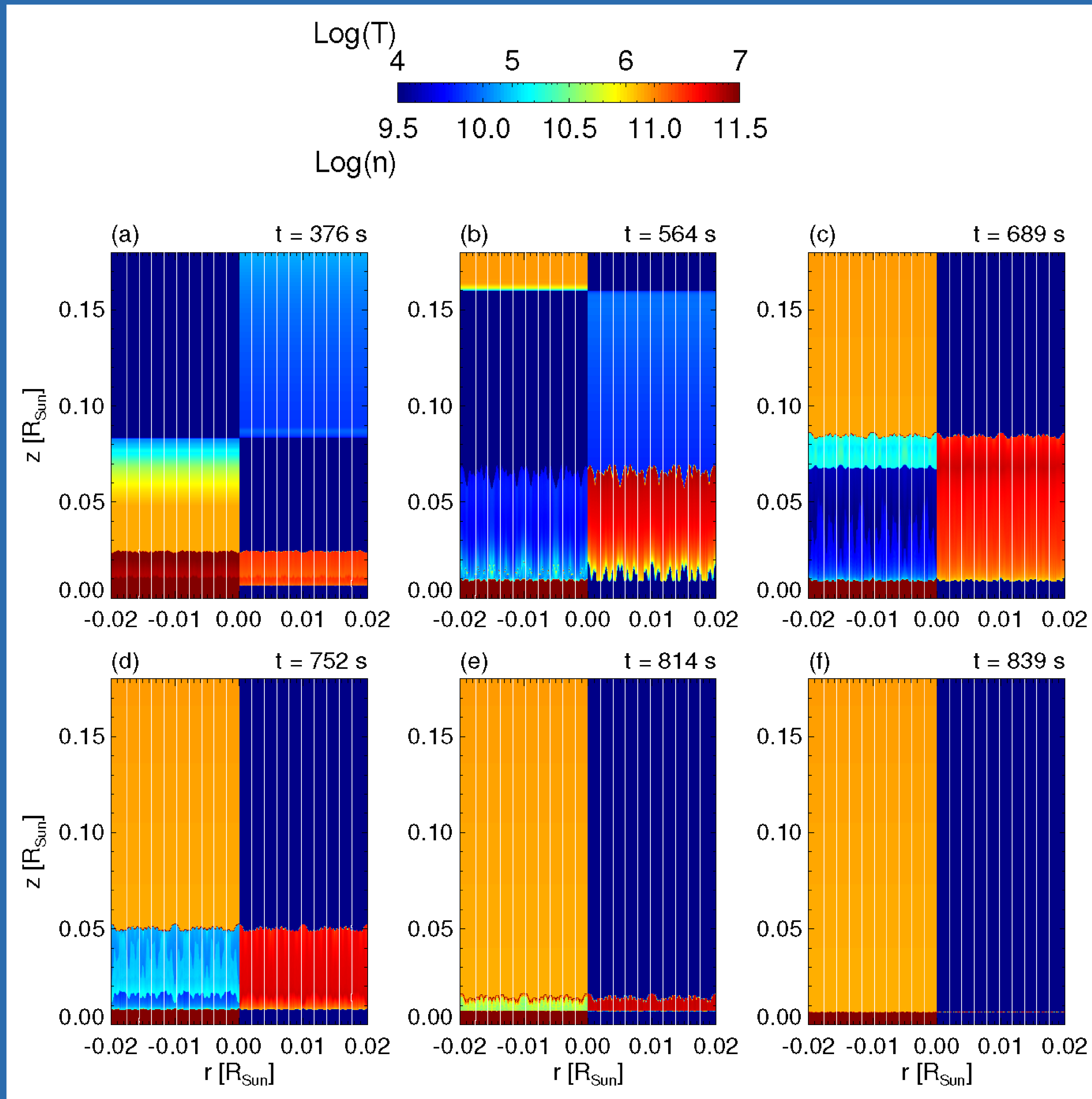


Figure 1: Evolution of density (left half-panel) and temperature (right half-panel) in log scale of plasma for the refence case of a train of blob. White lines represent magnetic field lines (Colombo et al. 2016).

Results and Conclusion

The impacts of accreting blobs onto stellar chromosphere produce reverse shock propagating through the blobs and shocked upflows. These upflows hit and shock back the next downfalling fragments (see Fig. 1 and 2).
As a result:

- Different velocities, densities and temperatures coexist in the shock region
- In each component of the CIV (1550 A) doublet we see a slow component (SC) shifted at 50 km $s^{-1}$and a fast component (FC) with redshift ranging between 200 and 400 km s^{-1}. The former is due to post-shock plasma which cools down and decelerates at the base of the accretion column, the latter originates from plasma which cools down due to thermal instabilities and from the interaction of upflowing surges with downfalling blobs (See Fig. 3)
- Our simulations show that the relative intensity of the FC increases with the stream fragmentation
- Each line of OVIII (18.97 A) doublet is redshifted to speed of 150 km s^{-1}

Our model predicts CIV lines profile remarkably similar to the observed ones and explains their origin in a natural way as due to stream fragmentation.

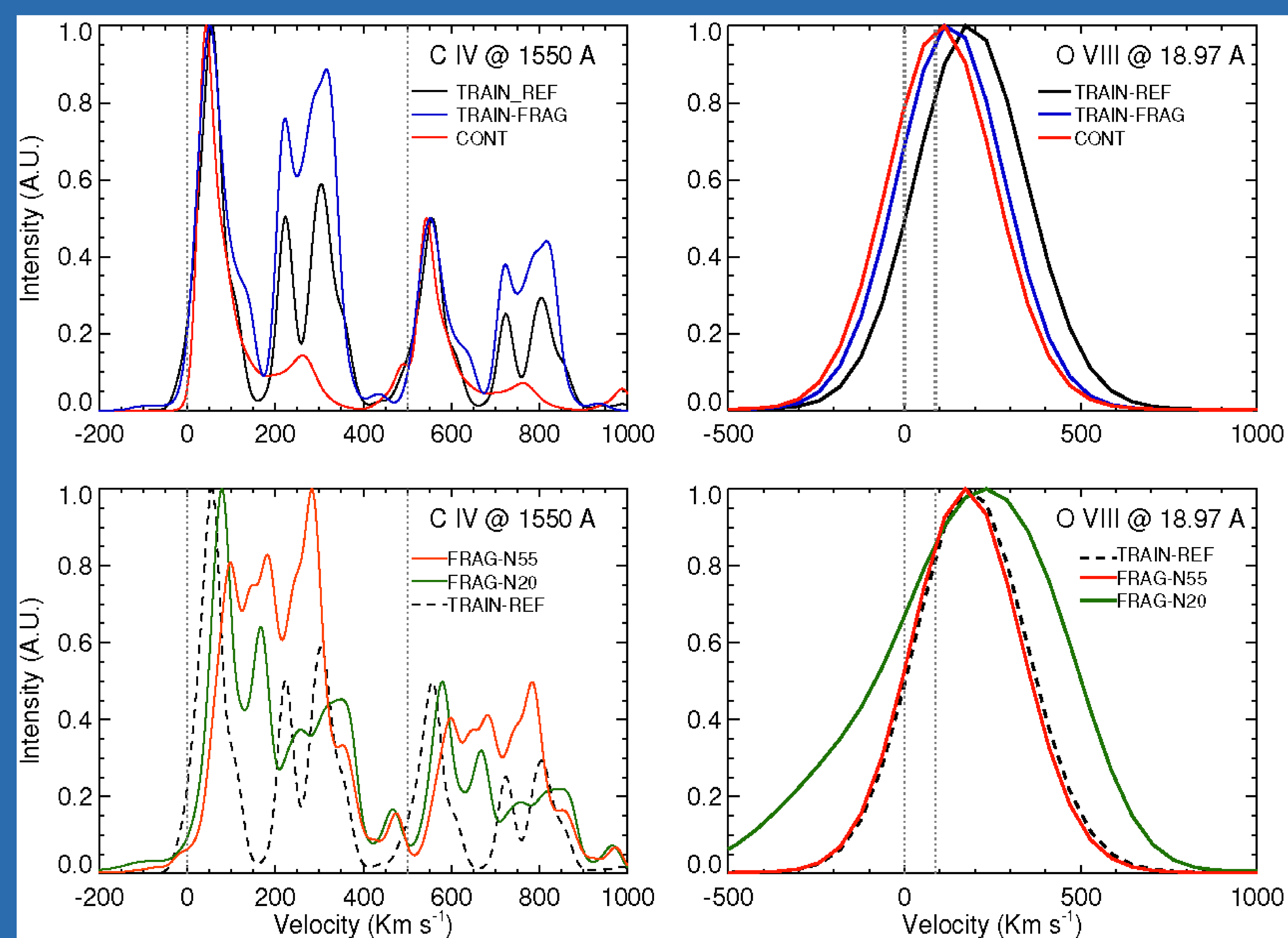


Figure 3: Synthetic profiles of CIV (left) and OVIII doublets (right); The top panel compares our reference simulation of a train of blobs (TRAIN-REF) with the case of a continuous stream (CONT) and with the case of a train of blobs with higher fragmentation (TRAIN-FRAG). The bottom panels show profiles from simulations of a randomly fragmented stream. The dotted grey lines mark the rest positions of the lines of the doublet. All the profiles are normalized to their maximum value. (Colombo et al. 2016)

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